Dietary fibre in legumes, seeds, vegetables, fruits and mushrooms : Comparing traditional and semi-automated filtration techniques

Pastell, Helena

2019-01

Pastell , H , Putkonen , T & Rita , H 2019 , ' Dietary fibre in legumes, seeds, vegetables, fruits and mushrooms : Comparing traditional and semi-automated filtration techniques ' , Journal of Food Composition and Analysis , vol. 75 , pp. 1-7 . https://doi.org/10.1016/j.jfca.2018.09.011

http://hdl.handle.net/10138/327560
https://doi.org/10.1016/j.jfca.2018.09.011

Original research article

Dietary fibre in legumes, seeds, vegetables, fruits and mushrooms: comparing traditional and semi-automated filtration techniques

Helena Pastell[a,*], Tiina Putkonen[a1], Hannu Rita[b]

[a]Finnish Food Safety Authority Evira, Mustialankatu 3, FI-00790 Helsinki, Finland

[b]Faculty of Agriculture and Forestry, P.O. Box 27 (Latokartanonkaari 7), FI-00014 University of Helsinki, Finland

* Corresponding author: Helena Pastell, Research and Chemistry Department, Finnish Food Safety Authority Evira, Mustialankatu 3, FI-00790 Helsinki, Finland, Tel. +358 50375 0968, email helena.pastell@evira.fi

[1]Present address: Finnish Safety and Chemicals Agency, PL 66 (Opastinsilta 12 B), FI-00521 Helsinki, Finland

Abstract

The method AOAC 2011.25 was used to analyze all the dietary fibre (DF) components included in the latest definition by the Codex Alimentarius Commission (2009). The traditional filtration technique, described in the method AOAC 2011.25, was compared with a new semi-automated filtration technique using Fibertec^{TM} 1023 system. For the comparisons, a statistical similarity approach was chosen to evaluate the results of six food matrixes (wheat flour, edible boletus, strawberry, tomato, green pea and horse radish). The total DF contents of the tested matrixes fit within 16% tightest data-induced similarity limit of the manual mean, with one exception (strawberry; 30%). Thus, it was concluded that both techniques are suitable for use with the method AOAC 2011.25, and therefore either technique was used to analyze a wide selection of legumes, seeds, vegetables, fruits and mushrooms (44 foods). Seeds were excellent sources of total DF, as well as water-insoluble (IDF) and water-soluble (SDFP) polysaccharides. A substantial amount of oligosaccharides (SDFS) was found in red onions. Generally, the DF contents were higher in this study than in earlier studies. Higher DF results can be partially explained by the more effective analytical method, and partly by changed varieties.

Keywords: Food analysis; Food composition; Method AOAC 2011.25; Dietary fibre (Dietary fiber); Legumes; Seeds; Vegetables; Fruits; Mushrooms; Similarity

1. Introduction

According to the latest definition by the Codex Alimentarius Commision (2009), dietary fibre (DF) is naturally occurring in food, isolated from food raw materials or synthetic health promoting carbohydrate polymers composed of ≥ 10 monomeric units, which are not hydrolyzed in the human

small intestine. Oligosaccharides with 3-10 monomeric units are also considered to be DF in the European Union (EU). DF contains numerous of chemically divergent substances which can be classified in several ways. Based on their solubility DFs can be divided as water-insoluble (e.g. cellulose, linear hemicelluloses and non-carbohydrate compound lignin) and water-soluble (e.g. highly substituted hemicelluloses, pectins, gums, mucilages, and oligosaccharides) components (Davidson & McDonald, 1998).

Revising the DF definition and including non-digestible oligosaccharides as a part of DF, alongside water-insoluble and water-soluble polysaccharides, gave rise to developing new analytical methods capable of analyzing all of these DF components. All the methods developed prior to the latest definition, are inadequate in measuring all the diverse poly- and oligosaccharides of DF. Only the latest methods AOAC 2009.01 and AOAC 2011.25 are able to analyze all the components, including, e.g., all types of resistant starch (RS), polydextrose, resistant maltodextrin, and non-digestible oligosaccharides (McCleary et al., 2013; Westenbrink et al., 2013; McCleary, 2014). Although the new methods have been available for several years, there are still limited amounts of publications with DF information given using the new methods.

The food composition databases (FCDBs) contain dietary fibre data obtained using various analytical methods, such as AOAC 985.29 (Prosky), AOAC 991.43 (Lee), Uppsala, Asp, Englyst and Southgate. Depending on the methods used, the existing data may under- or overestimate the amount of dietary fibre in several foods, and furthermore, the content of oligosaccharides is totally missing. However, data in the food composition databases (FCDBs) is utilized by many user groups (e.g. industry, dieticians, educators, consumers, risk assessors, researchers), and therefore precise dietary fibre content results are required for many purposes. Hence, more analytical results are needed.

Traditionally, many of the gravimetric DF analysis methods include filtering that is used to separate DF components based on their solubility and size. In many cases, the filtering step is time-consuming

and challenging because the filters get easily blocked. Because of this, new filtering techniques have been introduced, such as semi-automated Fibertec 1023 utilizing traditional crucible technique with possibility to use reversed pressure mode in filtration, automated Ankom Total Dietary Fibre Analyzer with filter bag technology and centrifugation technique by Medallion Labs (Plank & Povolny, 2015). Since fractionation is a crucial step in the DF assay, there is more need for research on the impact of the filtration techniques on the content results of individual DF fractions.

The introduction of new technologies as part of the DF analysis requires a statistical comparison between the techniques. Generally in food sciences, statistically significant differences are determined using a t-test to evaluate the potential of the methods. However, in addition to representing the significant differences, more attention should be focused on showing the similarity between the used methods or techniques. Rita and Ekholm (2007) studied the similarity of the results given by two methods used to determine algal-available phosphorus in pulp and paper mill wastewaters and proposed the use of the statistical similarity approach in environmental sciences. Schuirmann presented the statistical procedure in 1987, but it has not been widely used, neither in environmental nor in food sciences. According to Rita and Ekholm (2007), one reason for the limited utilization of the method may be the challenges in setting the similarity limit, which is required in the method.

The statistical hypothesis in similarity testing is the interval $S(\theta) = [-\theta, \theta]$, where the limit θ represents the largest tolerable difference between the averages of the two techniques in either direction. The methods are regarded as similar if the absolute value of their difference is below a positive value θ. The smaller θ is, the 'more' similar the means are. The hypothesis gains statistical support at a 5% level as soon as the 90% confidence interval [L, U] for the difference (L is the lower confidence limit and U the upper), is entirely within the similarity interval $[-\theta, \theta]$, i.e., $L > -\theta$ and $U < \theta$ (Rita & Ekholm, 2007).

Although the statistical technique to show similarity is simple, an appropriate limit θ to evaluate similarity is challenging for different matrixes. As the health effects of DF depend on its content and type, the limit θ should be set in such a way that conclusions for, e.g., nutritional recommendations or food related risk assessment remain unchanged irrespective of the technique used. It is often difficult to pre-set such a value for the similarity limit θ. The statistical methodology for showing similarity was originally developed in pharmaceutical drug development trials (Chow & Liu, 1999), where the similarity limit for two drug products to be bioequivalent is set as 20% in the guidelines given out by regulatory authorities. Such an issue-specific (pharmaceutical) limit cannot be transferred as such to be used in fibre content comparisons.

The aim of this study was to analyze precise and up-to-date DF contents (water-insoluble DF, water-soluble DF and non-digestible oligosaccharides) of legumes, seeds, vegetables, fruits and mushrooms, according to the latest DF definition using the AOAC 2011.25 methodology. Furthermore, the objective was to compare the DF results between the traditional and semi-automated filtration techniques, and use the statistical similarity approach in the comparisons.

2. Materials and methods

2.1. Materials

Pancreatic α-amylase (E-PANAA, 150,000 Ceralpha Units/g), amyloglucosidase (E-AMGDF, 3300 Units/mL) and purified protease (E-BSPRT, 350 tyrosine Units/mL) were purchased form Megazyme (Bray, Co., Wicklow, Ireland). D-sorbitol (used as an internal standard), LC Retention Time Standard (maltodextrins plus maltose, 4:1), filtration aid Celite® (acid washed, G-CEL500), and ion exchange resins Amberlite® FPA53 (OH^-; G-AMBOH) and Ambersep® 200 (H^+; G-AMBH), were all purchased from Megazyme.

Legumes: Broad bean (*Vicia faba*, 8 subsamples); common bean (*Phaseolus vulgaris*, 12); dried green pea (*Pisum sativum var. sativum*, 12); green Pea (*Pisum sativum var. sativum*, 12); sugar pea (*Pisum sativum var. macrocarpon*, 11). **Seeds:** Chia seed, whole (*Salvia hispanica*, 10); hempseed, whole and peeled (*Cannabis sativa*, 5 and 8, respectively); linseed, whole (*Linus usitasissium*, 12); pine nut, peeled (*Pinus spp.*, 12); poppy seed, whole (*Papaver somniferum*, 6); pumpkin seed, peeled (*Cucurbita pepo*, 13); sesame seed, whole and peeled (*Sesamum indicum*, 7 and 8, respectively); sunflower seed, peeled (*Helianthus annuus*, 12). **Vegetables:** Carrot (*Daucus carota*, 12); coriander (*Coriandrum sativum*, 12); horseradish (*Armoracia rusticana*, 10); lamb´s lettuce, i.e., corn salad (*Valerianelle locusta*, 7); lettuce (*Lactica sativa*, 12); pea shoot (*Pisum sativum*, 13); radicchio (*Cichorium intybus var. foliosum*, 8); red onion (*Allium cepa*, 12); romaine lettuce (*L. sativa var. longifolia (L. romana)*, 11); rucola, i.e., salad rocket (*Eruca sativa*, 12); tomato, Finnish and imported (*Solanum lycopersicum*, 12 and 9, respectively); white radish, i.e., daikon (*Raphanus sativus var. longipinnatus*, 12). **Fruits:** Apple, green, with and without skin, (*Malus pumila*, 12); apple, red, with and without skin (*Malus pumila*, 12); banana, peeled (*Musa Cavendish*, 12); blackcurrant (*Ribes nigrum*, 12); blueberry (*Vaccinium myrtillius*, 8); cloudberry (*Rubus chamaemorus*, 11); lingonberry (*Vaccinium vitis-idaea*, 12); raspberry, (*Rubus idaeus*, 13); Strawberry (*Fragaria sp.*, 12). **Mushrooms:** Chanterelle (*Cantharellus cibarius*, 13); edible boletus (*Boletus edulis*, 12); funnel chanterelle (*Craterellus tubaeformis (formerly Cantharellus tubaeformis)*, 10); northern milk-cap (*Lactarius trivialis*, 10). **Other:** Seaweed Nori (*Porphyra laciniata*, 1).

Food matrixes for internal verification: Dark wheat flour (endosperm and bran inner layer; T. aestivum L.), root vegetable mixture (containing orange and yellow carrot (*Daucus carota*), yellow turnip (*Brassica napus*), parsnip (*Pastinaca sativa*), and celery (*Apium graeveolens*)) and tomato (the scientific name given above).

Food matrixes for filtration technique comparisons: dark wheat flour, tomato, strawberry, edible boletus, pea shoot and horseradish (the scientific names given above).

The following foods contained samples entirely of Finnish origin: Lettuce, romaine lettuce, pea shoot, coriander, blackcurrant, lingonberry, blueberry, cloudberry, edible boletus, northern milk-cap, funnel chanterelle, (domestic) tomato, carrot, and dark wheat flour. Furthermore, the formed composite samples of dried green pea, rucola, red onion, raspberry and strawberry contained foods, of which 75% were grown in Finland, and the rest in other European countries. The origin of the seeds was multi-national, global even (Europe, Africa, Asia, Middle or South America). Imported tomatoes were Spanish with one exception (Holland), apples came from France, Italy and Austria, while bananas were Costa Rican (one sample from Brazil).

2.2. Sampling

The legume, vegetable, fruit and mushroom samples were purchased from the grocery stores and market places in Southern Finland based on availability. The seeds were purchased from Finnish grocery stores, health food shops, oriental shops and web stores. The market situation was first investigated, and the stores were chosen based on availability of the seeds. All the collected samples were the most representative brands in Finland in their category, in some categories, all the brands on the market were purchased. Most of the composite samples consisted of at least 12 subsamples, but in some cases less than 12 were accepted due to poor availability.

2.3. Sample pretreatment

An equal portion of each sample of legumes, vegetables, fruits and mushrooms were mixed individually into one composite sample by species. The composite samples were weighed prior to

and after freeze-drying to determine the weight loss during drying. The samples were freeze-dried on average for seven days (< -90°C, < 10^{-4} hPa (mbar); Scanvac CoolSafe, LaboGene ApS, Lynge, Denmark). They were individually homogenized by mixing, after which an equal portion of each sample was mixed into one composite sample by species. Seeds contained >10% fat, and were thus de-fatted according to AOAC 985.29 by treating the samples with petroleum ether prior to milling and DF analysis.

2.4. Method AOAC 2011.25

All the samples were milled through a 0.5 mm sieve. The DF was analysed according to the method AOAC 2011.25 (Megazyme, 2013). The sample (an exact amount of 1.000 ± 0.005 g, or in case of mushroom samples 0.500 ± 0.005 g to facilitate the filtering step) was weighed in an incubation bottle. An enzyme mixture of pancreatic α-amylase/amyloglucosidase (AMG) was added to each bottle to remove starch, and the samples were incubated for 16 hours at 37°C in a shaking water-bath. Next, protease was added (30 minutes, 60°C) to remove proteins. Water-insoluble (IDF) and water-soluble polysaccharides (SDFP; DF soluble in water and precipitated by 78% aqueous ethanol) and oligosaccharides (SDFS; DF soluble in water and not precipitated by 78% aqueous ethanol) were analyzed as separate fractions. The enzymatically hydrolyzed samples were filtered twice to separate IDF from SDF (soluble dietary fibre), and SDFP from SDFS. IDF and SDFP residues were dried, weighed and corrected for protein and ash values. SDFS was hydrolyzed by AMG and analysed by high performance liquid chromatography (HPLC) after deionization, as described in Rainakari et al. (2016). Sorbitol was used as an internal standard for SDFS analysis. The total DF amount is the sum of IDF, SDFP and SDFS. The DF contents were expressed in fresh weight (g/100 g) and therefore corrected by moisture. De-fatted samples were corrected by fat. Dry weights were only used for statistical treatment.

184

185 **2.5.Filtration techniques**

186 Two different filtration techniques, referred to as manual and semi-automated technique, were
187 compared. In the manual filtration technique, the samples were filtered through the fritted crucibles
188 with the help of an air-driven vacuum pump (PIAB, Lab Vac LVH40; Sigma-Aldrich, St. Louis, MO,
189 USA) or water-suction. Fibertec^{TM} 1023 equipment (FOSS, Hillerød, Denmark) connected to water-
190 suction was used in semi-automated technique. The main differences in the techniques are collected
191 in Table 1. According to the AOAC method 2011.25, the bed of Celite® is wetted in the crucible,
192 and using suction, drawn onto the fritted glass as an even mat (Megazyme, 2013). If the sample forms
193 a viscose solution and the filtration is slow, in the manual filtration technique, the sample may be
194 stirred gently without breaking the Celite®-layer. However, when the semi-automated technique is
195 used, and if the backpressure is applied to accelerate the filtration, Celite® is mixed partially or
196 completely with the sample matrix. In both techniques, similar fritted crucibles with the same pore
197 size (coarse, ASTM 40-60 μm) are used.

198

199 **2.6.Verification of the method AOAC 2011.25**

200 At Evira, an official method AOAC 2011.25 was adopted in use through the internal verification
201 procedure and accreditation. Verification was done using manual filtration technique with three
202 different food matrixes: dark wheat flour, tomato and root vegetable mixture, which were pre-treated
203 according to the AOAC 2011.25 method, and are further used as inter-laboratory control samples.
204 Also the fat removal from the samples prior to DF analysis was verified to expand the usability of the
205 method for the matrixes with fat-content over 10%. Repeatability and reproducibility were tested for
206 the gravimetric analyses of polysaccharides (IDF and SDFP) and fat removal. Limit of detection

(LOD) and limit of quantification (LOQ) were determined for the HPLC analysis of the oligosaccharides (SDFS).

For implementation of semi-automated filtration technique, six different food matrixes (dark wheat flour, tomato, strawberry, edible boletus, pea shoot and horseradish) were analyzed as 5-7 parallel samples each. The same samples (as 3 parallels) were also analyzed using the verified method with manual filtration technique, and the results were compared. The suitability of the semi-automated system was evaluated based on this comparison.

2.7. Statistical testing

Manual and semi-automated filtration techniques were analyzed to test whether their average results are close enough to each other, i.e., that the techniques give similar results. The statistical similarity approach was used, but due to difficulties in pre-setting the similarity limit θ for DF contents, a data exploration technique (Rita & Ekholm, 2007) was utilized. It results in the smallest similarity limit value that – if this value for θ in the similarity hypothesis $S(\theta)$ could have been specified in advance – would have been formally supported by the present data exactly at a specified (e.g., 5%) level. The resulting estimate is called the tightest data-induced (TDI) similarity limit and denote it by θ_{TDI}, which corresponds the term 'potential similarity limit' in Rita & Ekholm (2007). The TDI-value is determined by taking the larger absolute value of the endpoints of the 90% two-sided confidence interval for the difference. The resulting similarity hypothesis $S(\theta_{TDI}) = [-\theta_{TDI}, \theta_{TDI}]$ gains support at exactly the 5% level.

The proportion of the used technique`s influence of the total variation of DF content was determined. Coefficient of determination (R^2) corresponds to this proportion, and analysis of variance (ANOVA) was used to calculate R^2 values.

3. Results and Discussion

3.1. Verification of the method AOAC 2011.25

The method AOAC 2011.25 has been validated and evaluated through a collaborative study by McCleary et al. (2012). In internal verification of the method AOAC 2011 (using manual filtration), the standard deviation (SD) and the coefficient of variation (CV%) of total DF content were calculated to express the precision and repeatability of the assay. SD and CV%, respectively, were 0.62 and 11.2 (wheat flour, n=20), 1.81 and 8.4 (tomato, n=20) and 0.42 and 1.5 (root vegetable mixture, n=10). McCleary et al. (2012) reported that within-laboratory variability SD for TDF ranged from 0.47 to 1.41 and between-laboratory from 0.95 to 3.14 in the method validation. Thus, the analysis results are in accordance with the method requirements established in the validation. For implementing the semi-manual filtration technique, SD and CV% were determined for all six food matrices involved. SD ranged from 0.6 to 4.0 (CV% 4.0-19.0), with the highest SD for strawberry, and for other matrices less than 1.5. The results obtained by semi-automatic filtration technique, apart from strawberries, are in the same range as in initial validation and internal verification.

The limit of detection (LOD) and the limit of quantification (LOQ) in the HPLC analysis of the oligosaccharides were determined as 0.1 g/100 g and 0.2 g/100 g, respectively. Repeatability of the de-fatting was also investigated in several foods, resulting in CV percentages between 0.1 - 2.8 (SD 1.12-1.50). Low CV% indicate that de-fatting works fine. According to validation and verification guidelines (FDA, 2015), a method verified for three or more matrixes, with similar proximate composition as the foods to be analyzed, is considered to be suitable for the DF analysis for a wider range of foods as well.

3.2. Comparison of the technique averages among six food matrixes

The means of total DF based on the semi-automated filtration technique differed upwards from those of the manual reference technique for wheat flour (by 6%) and edible boletus (7%) and downwards for strawberry (-10%), tomato (-3%), pea shoot (-2%) and horseradish (-8%). The percentages were calculated from the averages given in Table 2. The proportional differences were fairly small, and only in marginal cases may result in misclassification of, e.g., "source of fibre" (3 g of fibre per 100 g) as "high in fibre" (6 g). This could have taken place for wheat flour, as the observed total DF contents were close to the class limit 6 g.

The difference among the means of IDF obtained with the two techniques was at most 20%, but for SDFP and SDFS, the difference was larger in most cases. However, the SDFP in wheat flour was only 8% higher in manual technique, and for SDFS in edible boletus, 2% lower than in semi-automated filtration technique. In tomato, SDFS content was smallest of all six matrixes and the results varied considerably, but most of the observations were below LOQ, which impedes conclusion making.

The six food matrixes included in the technique comparison varied in their DF profiles. Cereals primarily contain hemicelluloses, cellulose and β-glucan, whereas vegetables contain proportionally more gelling fibers than cereals, e.g., pectins, mucilages and gums (Elleuch et al., 2011). Furthermore, only mushrooms contain α-glucan and chitin (Nile & Park, 2014). These differences in the DF compositions may affect the filtration step, and thus the contents of individual DF fractions. Further research is required for firmer conclusions regarding their effects and role in the similarity of the techniques' results.

3.3.Similarity and the residual variation among six food matrixes

277 The observed relative average differences do not, however, tell the whole truth as they bypass the
278 effects of noise, i.e., measuring error and sampling variation. To relate the observed differences
279 between the techniques to the amount of these uncontrolled sources of variation, analysis of variance
280 (ANOVA) was used. It gave the proportion of the total variation that is due to the difference between
281 the two techniques. In regression context, this proportion corresponds to the coefficient of
282 determination, commonly denoted by R^2. It tells which proportion of the total variation of DF content
283 can be addressed to the explanatory variable, which, in this case, is the technique. Contrary to standard
284 regression, small values of R^2 are now desirable as they indicate the similarity of the techniques. This
285 is because, for small R^2, most of the variation in the observations is addressed to noise and very little
286 to the average difference between the techniques.

287 The proportions of total variation due to difference between the techniques (coefficients of variation
288 R^2) were for total DF and IDF, respectively, 4.2% and 28.5% (for wheat flour), 30.6 and 5.5 (edible
289 boletus), 1.6 and 0.1 (strawberry), 2.0 and 18.4 (tomato), 4.2 and 10.7 (pea shoot) and 59.5 and 0.2 %
290 (horseradish). For the components SDFP and SDFS, the percentages were 2.5 and 55.4 (wheat flour),
291 68.6 and 1.2 (edible boletus), 33.1 and 39.2 (strawberry), 33.9 and 39.2 (tomato), 63.4 and 41.3 (pea
292 shoot) and, finally, 86.9 and 18.4 (horseradish).

293

294 **3.4.Evaluation of TDI similarity limits of six food matrixes**

295 Next, the tightest data induced similarity limits (TDI) were related to the reference (manual filtering)
296 averages (Table 2). As the limit is based on a confidence interval, it takes into account variation
297 among the parallel samples, and gives a realistic view of the degree of similarity that potentially gains
298 statistical support from the present data (which is not available by only inspecting the averages). Two
299 averages may be very close to each other, yet, if there is a lot of residual variation, this could be just
300 a coincidence.

For total DF contents, TDI was within 16% of the manual mean for the tested food matrixes, except for strawberry, where θ_{TDI} was 30% of the reference mean. For IDF, 44% covers θ_{TDI} of all six foods, strawberry being again responsible for the highest limit, as the other five studied foods fall within 31% of the reference. For the remaining two fractions, TDI limits reflect the high relative variability (mostly due to several observations below LOQ). This seriously counsels to abstain from overly assertive opinions regarding the similarity of the techniques for these two DF components.

Since the exploration (TDI-technique) was used in evaluating the similarity, and there is no actual regulation of the magnitude concerning the accepted difference between the techniques, the magnitude of the results can be estimated by comparing them with the internal variation of the manual technique in verification. In wheat flour, CV% for total DF, IDF, SDFP and SDFS were 12%, 13%, 22% and 33%, respectively. For tomato, the corresponding values were 10%, 11%, 19% and 187% (Table 2). Despite some of the foods having had higher θ_{TDI}, the results were in the order of the variation observed within the manual technique. The most important is that the total DF results are similar. It is more difficult to determine what should be the absolute amounts of IDF, SDFP and SDFS, and which technique gives results that are closest to the correct content. For that, further research is required. Thus, perhaps, at least for the time being, it can be stated that similarity of the techniques is adequate for using either one.

3.5.Similarity approach versus testing for difference

Standard t-test is commonly used in food science to determine whether there is statistically a significant difference between data sets. In practice, if large p-values (>0.05) are obtained, the data sets are often argued to be similar. However, strawberry in the data gives an outstanding example of how fatally erroneous conclusions ‘large p-value argument’ for similarity may lead. For it, difference between the two techniques for the total DF contents was not statistically significant: t-test, p = 0.54

(or 0.67, if one does not assume equal variances within the techniques). As 0.54 > 0.05, similarity of the two techniques would have been concluded based on t-test. However, for strawberry, the tightest data induced total DF similarity limit θ_{TDI} was the largest of all six matrixes, i.e., 7.09 g/100 g; 30% (Table 2).

On the other hand, for horseradish, a smaller difference in the total DF content (-2.07 g/100 g; Table 2) resulted in statistical significance ($p < 0.01$); yet θ_{TDI} was only 12% of the reference mean. For strawberry, the large p-value is due to large standard error of the difference (2.48, largest among the six matrixes), whereas, for horseradish, standard error was only 0.60.

It is worth noting that similarity and existence of a difference do not exclude each other. Even a small difference can be statistically significant when testing for difference (especially when the number of replicates is large) and, at the same time, within the similarity tolerance limits, especially for large values of the tolerance θ. Which results are relevant, depends on the objective(s) of the study. In addition, this emphasizes the fact that testing for similarity calls for quantitative specification of the limit θ whereas testing for difference does not.

3.6.Dietary fibre contents in legumes, seeds, vegetables, fruits, and mushrooms

The analyzed total DF contents as fresh weights varied from 1.2 g/100 g in lamb´s lettuce to 36.3 g/100 g in whole chia seeds (Table 3). In addition to chia seeds, many other seeds, such as whole linseeds and whole hempseeds contained substantial amounts of DF (35.0 g/100 g, fresh weight). Although most seeds contained DF abundantly, peeled hemp seeds and peeled pine nuts are not considered to be high fibre foods. The limits for nutritional claims “high in fibre” and “source of fibre” are 6 g of fibre per 100 g and 3 g of fibre per 100 g, respectively (EC Regulation, 2006). Most of the studied berries can be considered as good sources of fibre, as their DF content were 3.0-6.5

348 g/100 g (fresh weight). Generally, the largest component of DF was IDF in the analyzed foods, as
349 expected. The foods contained 58-95% IDF of the total DF, only in red onions less than that, as the
350 corresponding ratio was 17%. Proportionally the lowest amount of IDF was found in pine nuts and
351 the highest in imported tomatoes. The best sources for IDF were linseeds, chia seeds and hempseeds,
352 consumed as whole (ca. 30 g/100 g, fresh weight). The range of SDFP in foods was 4-37% of total
353 DF. Proportionally most SDFP was found in seaweed Nori, green apples, peeled hemp seeds, peeled
354 pine nuts and carrots. Absolut amounts for SDFP are the highest in seeds. Apart from red onion (4.4
355 g/100g, fresh weight), the oligosaccharides (SDFS) were only found in small amounts from seeds,
356 which contained 0.7-1.8 g/100 g (fresh weight) SDFS. Only traces (mostly under LOQ) of SDFS was
357 detected in other vegetables, fruits, and mushrooms.

358 Most of the results obtained by the method AOAC 2011.25 in this study are bigger than the values
359 presented in Finnish Food Composition Database Fineli earlier (Table 3). As big as two- or even
360 threefold differences were found in the total DF content in red onions, broad beans, green peas and
361 bananas. Red onions contained considerable amounts of oligosaccharides, which were not measured
362 by the earlier methods. Legumes are known to contain naturally occurring resistant starch types 1 and
363 2 (RS1, RS2), while green bananas are a source of RS2 (Fuentes-Zaragoza et al., 2010). The classical
364 analytical methods for DF are able to measure only retrograded starch/amylose (RS3), which is
365 formed when starch containing foods are cooked and cooled, and is predominant RS in most food
366 products. In addition to RS3, other RS types (RS1, RS2 and RS4) are also analyzed by the method
367 AOAC 2011.25 (Westenbrink et al., 2013). RS concentrations in legumes and unripe bananas are
368 high (mean 25% and 52%, respectively), which may partially explain the observed differences in their
369 DF content (Fuentes-Zaragoza et al., 2010). Brummer et al. (2014) reported that cooked pulses
370 contained 3.75-4.66 g/100 g resistant starch and 1.5-4.5 g/100 g non-digestible oligosaccharides
371 (raffinose, verbascose and stachyose) on a dry weight basis. The amount of oligosaccharides varied
372 also in the studied legumes with the highest content measured in dried green peas (2.45 g/100 g)

which is in the same range with the above mentioned study. Although the resistant starch was not separately measured, it surely explains, together with oligosaccharides, at least partially the differences in total DF contents between this study and Fineli database. The degree of ripeness of the measured banana samples has a high impact on the amount of RS2, and hence on the total DF content. Garcia-Amezquita et al. (2018) reported the DF content in banana as 26% higher by the method AOAC 2011.25 compared to AOAC 991.43 due to presence of RS2. The ripeness of the banana samples was not defined in this study, but it can be one of the influential factors together with the method used, since the total DF content of bananas was analyzed to be 50% higher compared to the previous value in Fineli database.

Other observed differences can partially be explained by the distinctions in the analyzed food samples. Those are, e.g., the variation in plant genetics and growth-influencing aspects, such as soil and weather conditions of the growing season. The influence of different analytical methods was investigated in the article of McCleary et al. (2013), where the methods AOAC 985.29, 2009.01 and 2011.25 were compared. The method AOAC 985.29 has been widely used to analyze the total DF content, and the AOAC 2009.01 method is an improved version of it, with considerable changes in the analytical conditions (enzymes, temperatures). The difference between the new methods AOAC 2011.25 and 2009.01 is, that the former analyzes IDF, SDFP and SDFS separately, while the latter gives the results as HMWDF (high molecular weight DF) and SDFS. According to McCleary et al. (2013), the content of HMWDF in green bananas was 5.0 times bigger, and in ripe banana still 4.7 times higher measured by AOAC 2009.01 than by AOAC 985.29, representing the earlier mentioned underestimation of RS by the older methods. In beans and peas, the total DF content was 16-21% higher, measured by 2009.01 than 985.29. Carrots were analyzed using all three methods, and all the results were almost identical (McCleary et al., 2013). The SDFS amounts of the present study are well in line with the ones obtained by McCleary et al. (2013). The DF composition of the food determinates the amount of the total DF analyzed by the various methods. Currently, the safest

solution is to use the methods AOAC 2009.01 and 2011.25 to ensure the analysis of all the components. The total DF results are similar enough for one to choose either filtering technique, manual or semi-automated.

4. Conclusions

Two different filtering techniques, manual and semi-automated, were evaluated with respect to the similarity of DF content measurements. Showing similarity calls for a different statistical technique than testing of difference. The very definition of similarity requires pre-setting of tolerance, i.e., the largest acceptable difference θ between the means. In problematic cases, where pre-setting of θ is not possible, the tightest data induced limit, θ_{TDI}, is useful in evaluating the degree of similarity. It takes the effects of sample size and noise into account, as any statistically valid method shall. Based on similarity approach, it can be stated, that similarity of the techniques is adequate for using either one. However, some foods, such as strawberries, may well behave aberrantly during filtration as several DF components (such as pectin, hemicelluloses and lignin) and their countless combinations presumably affect the filtration. Today, the mechanisms remain opaque and call for further research on the topic. Finally, the DF content of legumes, seeds, vegetables, fruits and mushrooms was analyzed by the method AOAC 2011.25 with varying filtering technique due to similarity evaluation results above. The measured total DF results were mostly bigger than the previous values obtained by the older methods, because when the method AOAC 2011.25 is used, e.g., oligosaccharides and RS are included in DF as well, in contrast to the preceding methods.

Acknowledgements

The Ministry of Agriculture and Forestry is acknowledged for financial support of this study. We thank biostatistician Heli Rita for intensive discussions of the concept and practices of similarity. Aliki-Ilona Rainakari, Jarkko Larkio, Marika Kilpinen, Irmeli Komulainen, Kristiina Kuitunen and Soile Penttinen are thanked for their analytical work.

References

Brummer, Y., Kaviani, M., Tosh, S. (2014). Structural and functional characteristics of dietary fibre in beans, lentils, peas and chickpeas. *Food Research International, 67,* 117-125.

Callaway, J. C. (2004). Hempseed as a nutritional resource: An overview. *Euphytica, 140,* 65-72.

Chow, S.-C., Liu, J.-P. (1999). Design and analysis of bioavailability and bioequivalence studies. CRC Press.

Codex Alimentarius Commision. (2009). Alinorm 09/32/26. Retrieved May 30, 1917 from: www.fao.org/input/download/report/710/al32_26e.pdf

Danish food composition databank. Retrieved May 30, 2017 from: http://www.foodcomp.dk/

Davidson, M. H., McDonald, A. (1998). Fiber: Forms and functions. *Nutrition Research, 18*, 617-624.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C., Attia, H. (2011). Dietary fibre and fibre-rich by-products of food processing: Characterisation, technological functionality and commercial applications: A review. *Food Chemistry, 124*, 411-421.

FDA, US Food & Drug Administration Office of Foods and Veterinary Medicine. (2015) Guidelines for the Validation of Chemical Methods for the FDA FVM Program. *2nd Edition.*

445 Fineli Food Composition Database release 17. Retrieved May 30, 2017 from: www.fineli.fi

446 Fuentes-Zaragoza, E., Riquelme-Navarrete, M. J., Sánchez-Zapata, E., Pérez-Álvarez, J. A. (2010).
447 Resistant starch as functional ingredient: A review. *Food Research International, 43,* 931-942.

448 Garcia-Amezquita, L. E., Tejada-Ortigoza, V., Heredia-Olea, E., Serna-Saldívar, S. O., Welti-
449 Chanes, J. (2018). Differences in the dietary fiber content of fruits and their by-products
450 quantified by conventional and integrated AOAC official methodologies. *Journal of Food*
451 *Composition and Analysis, 67,* 77-85.

452

453 Livsmedelsdatabasen. Retrieved May 30, 2017 from: http://www.slv.se/en-gb/Group1/Food-and-
454 Nutrition/The-Food-Database/

455

456 Mattila, P., Salo-Väänänen, P., Könkö, K., Aro, H., Jalava, T. (2002). Basic composition and amino
457 acid contents of mushrooms cultivated in Finland. *Journal of Agricultural and Food*
458 *Chemistry, 50,* 6419-6422.

459 McCance, R., Widdowson, E. (1960). The composition of foods. *London: HM Stationery Office.*
460 MRC special report series no. 297.

461 McCleary, B. V. (2014). Modification to AOAC official methods 2009.01 and 2011.25 to allow for
462 minor overestimation of low molecular weight soluble dietary fiber in samples containing
463 starch. *Journal of AOAC International, 97,* 896-901.

McCleary, B. V., DeVries, J. W., Rader, J. I., Cohen, G., Prosky, L., Mugford, D. C., Champ, M., Okuma, K. (2012). Determination of insoluble, soluble, and total dietary fiber (CODEX definition) by enzymatic-gravimetric method and liquid chromatography: Collaborative study. *Journal of AOAC International, 95*, 824-844.

McCleary, B. V., Sloane, N., Draga, A., Lazewska, I. (2013). Measurement of total dietary fiber using AOAC method 2009.01 (AACC international approved method 32-45.01): Evaluation and updates. *Cereal Chemistry Journal, 90*, 396-414.

Megazyme. (2013). Integrated total dietary fiber assay procedure. Including resistant starch and non-digestible oligosaccharides. AOAC method 2009.01 & 2025.11 and AACC method 32-45.01 & 32-50.01. Updated format. Retrieved May 30, 1917 from: https://secure.megazyme.com/files/booklet/k-intdf_data.pdf

Møller, A., Saxholt, E. (1996). Food composition tables. LST.

Nile, S. H., Park, S. W. (2014). Total, soluble, and insoluble dietary fibre contents of wild growing edible mushrooms. *Czech Journal of Food Sciences, 32*, 302-307.

Plaami, S. P., Kumpulainen, J. T., Tahvonen, R. L. (1992). Total dietary fibre contents in vegetables, fruits and berries consumed in Finland. *Journal of the Science of Food and Agriculture, 59*, 545-549.

Plank, D. W., Povolny, L. A. (2015). Improvements to the dietary fiber methods used for food analysis. Dietary fiber isolation by centrifugation. Retrieved January 19, 2017 from http://www.foss.dk/campaign/rethinkfibre/

Rainakari, A., Rita, H., Putkonen, T., Pastell, H. (2016). New dietary fibre content results for cereals in the Nordic countries using AOAC 2011.25 method. *Journal of Food Composition and Analysis, 51*, 1-8.

Regulation (EC) no 1924/2006 of the European parliament and of the council of 20 December 2006 on nutrition and health claims made on foods. (2006). Retrieved 30 May, 2017 from: http://data.europa.eu/eli/reg/2006/1924/2012-11-29

Rita, H., Ekholm, P. (2007). Showing similarity of results given by two methods: A commentary. *Environmental Pollution, 145*, 383-386.

Schuirmann, D. J. (1987). A comparison of the two one-sided tests procedure and the power approach for assessing the equivalence of average bioavailability. *Journal of Pharmacokinetics and Biopharmaceutics, 15*, 657-680.

USDA Food Composition Databases. Retrieved September 11, 2018 from: https://ndb.nal.usda.gov/ndb/search/list

Westenbrink, S., Brunt, K., van der Kamp, J. (2013). Dietary fibre: Challenges in production and use of food composition data. *Food Chemistry, 140*, 562-567.

504 Table 1. Comparison of the manual and semi-automated technique in dietary fibre analysis.

Variable	Manual technique	Semi-automated technique
Instrumentation	Water-suction or air-driven vacuum pump	FOSS Fibertec™ 1023 connected to water-suction
Incubation bottles	250 mL Fisherbrand® soda glass bottle or similar	600 mL bottle with removable bottom (FOSS)
Fritted crucibles	Gooch, fritted disk, 50 mL, pore size coarse, ASTM 40-60 μm	Gooch, fritted disk, 30 mL, pore size coarse, ASTM 40-60 μm
Procedure if filter is clogged	Gentle manual stirring without breaking the Celite®-layer	Reversed pressure to open the pores resulting in mixing up of Celite® and the sample matrix
Filtering time/sample*	5-30 min	1-5 min
Sample processing	One by one	Six samples at a time

505 ***** Filtration times can be much longer if the samples form strong viscose solutions.

506

507

508

509

510

511

512

513

514

515

Table 2. Similarity of the results of dietary fibre (DF) composition analysis based on the filtration techniques 'semi-automated' (Semi-auto) and 'manual' (Manu). Tightest data-induced similarity limits θ_{TDI} corresponding to 5% risk in similarity testing are given for each matrix (see text). Means are expressed as g/100 g (dry weight).

	N		Mean		SD		SE					Tightest data-induced limit	
Matrix	Semi-auto	Manu	Semi-auto	Manu	Semi-auto	Manu	Semi-auto	Manu	Mean difference (Semi-auto – Manu)	SE of difference	CI (90%) for difference	θ_{TDI}	%[2]
Wheat flour													
Total DF	6	20	5.87	5.56	0.617	0.654	0.252	0.146	0.310	0.301	(-0.205, 0.825)	0.83	15
IDF			1.98	2.47	0.399	0.328	0.163	0.0734	-0.492	0.160	(-0.766, -0.217)	0.77	31[1]
SDFP			1.73	1.88	0.384	0.415	0.157	0.0929	-0.149	0.190	(-0.475, 0.177)	0.48	25
SDFS			2.16	1.21	0.229	0.402	0.0934	0.0898	0.946	0.173	(0.649, 1.24)	1.24	103[1]
Edible boletus													
Total DF	5	3	25.2	23.5	1.53	1.29	0.682	0.742	1.72	1.06	(-0.337, 3.78)	3.78	16
IDF			17.7	18.8	2.55	2.08	1.14	1.20	-1.04	1.75	(-4.45, 2.37)	4.45	24
SDFP			6.61	3.83	1.14	0.83	0.511	0.478	2.77	0.766	(1.28, 4.26)	4.26	111[1]
SDFS			0.866	0.880	0.0882	0.0173	0.0395	0.0100	-0.0140	0.0531	(-0.117, 0.0890)	0.12	13
Strawberry													
Total DF	6	3	20.9	23.3	3.96	1.98	1.62	1.14	-2.38	2.48	(-7.09, 2.32)	7.09	30
IDF			16.6	20.6	4.14	2.27	1.69	1.31	-4.02	2.62	(-8.98, 0.932)	8.98	44
SDFP			3.43	2.36	2.22	0.45	0.91	0.26	1.07	1.34	(-1.47, 3.61)	3.61	153
SDFS			0.873	0.300	0.456	0.125	0.186	0.0721	0.573	0.277	(0.0490, 1.10)	1.10	366
Tomato													
Total DF	6	20	21.0	21.7	1.52	2.17	0.622	0.485	-0.671	0.955	(-2.30, 0.963)	2.30	11
IDF			18.5	18.6	1.02	2.09	0.415	0.468	-0.133	0.893	(-1.66, 1.37)	1.66	9
SDFP			1.97	2.91	0.680	0.548	0.278	0.123	-0.945	0.269	(-2.17, -0.681)	2.17	48[1]
SDFS			0.543	0.132	0.100	0.247	0.0408	0.0553	0.412	0.105	(0.233, 0.591)	0.59	449[1]
Green pea													
Total DF	6	3	30.1	30.7	1.20	2.43	0.49	1.40	-0.643	1.16	(-2.85, 1.56)	2.85	9
IDF			27.4	26.4	0.684	2.51	0.279	1.45	0.945	1.03	(-1.01, 2.90)	2.90	11
SDFP			2.27	3.69	0.649	0.142	0.265	0.0818	-1.42	0.392	(-2.17, -0.681)	2.17	59[1]
SDFS			0.417	0.580	0.117	0.061	0.0478	0.0351	-0.163	0.0737	(-0.303, -0.0240)	0.30	52
Horseradish													
Total DF	7	3	23.8	25.8	1.01	0.120	0.381	0.0693	-2.07	0.604	(-3.19, -0.946)	3.19	12[1]
IDF			22.5	22.6	0.852	0.170	0.322	0.0984	-0.0695	0.512	(-1.02, 0.883)	1.02	5
SDFP			0.620	2.71	0.477	0.0737	0.180	0.0426	-2.09	0.286	(-2.62, -1.55)	2.62	97[1]
SDFS			0.611	0.530	0.100	0.0265	0.0380	0.0153	0.0814	0.0607	(-0.0310, 0.194)	0.19	37

[1] Significance in 'normal' t-test ($p<0.05$), where alternative hypothesis is 'the means differ'.

[2] Percentages are calculated with Manu-mean as reference.

N = amount of samples, SD = standard deviation, SE = standard error mean, CI = confidence interval

521 Table 3. The dietary fibre results from the Finnish vegetables, seeds, berries, mushrooms and fruits expressed as fresh
522 weights (g/100 g), n = 2-3 of each composite food sample. The values provided using earlier methods are presented in
523 the column 'Fineli', as they were obtained from the Finnish food composition database (Fineli).

524 DF = dietary fibre; IDF = water-insoluble DF; SDFP = DF soluble in water but precipitated by 78% aqueous ethanol (water-
525 soluble polysaccharides); SDFS = DF soluble in water and not precipitated by 78% aqueous ethanol (oligosaccharides)

Food	Moisture	IDF	SDFP	SDFS	Total DF	Fineli
Legumes						
Broad bean	69	8.61 ± 0.3	0.67 ± 0.1	0.70 ± 0.0	9.98 ± 0.2	4.2[1]
Common bean	88	3.63 ± 0.1	0.34 ± 0.0	<0.2	4.01 ± 0.1	2.4*
Dried green pea	13	15.4 ± 0.4	1.59 ± 0.1	2.45 ± 0.3	19.5 ± 0.6	20.0*
Green Pea	72	5.99 ± 0.0	1.27 ± 0.1	0.21 ± 0.0	7.47 ± 0.0	3.1*
Sugar pea	90	2.00 ± 0.1	0.23 ± 0.0	<0.2	2.23 ± 0.0	2.2[1]
Seeds						
Chia seed, whole	7.0	33.2 ± 2.1	1.54 ± 0.3	1.75 ± 0.2	36.3 ± 2.2	-
Hempseed, whole	7.1	30.2 ± 0.0	4.14 ± 0.2	0.71 ± 0.1	35.0 ± 0.3	27.6[2]
Hempseed, peeled	5.5	3.26 ± 0.2	1.58 ± 0.3	0.48 ± 0.0	5.40 ± 0.1	-
Linseed, whole	6.3	25.0 ± 0.6	4.78 ± 0.2	0.62 ± 0.0	30.4 ± 0.7	26.0[3]
Pine nut, peeled	1.4	3.19 ± 0.1	1.46 ± 0.0	0.77 ± 0.0	5.50 ± 0.0	3.7[1]
Poppy seed, whole	5.3	16.0 ± 0.7	2.28 ± 0.1	0.70 ± 0.1	19.0 ± 0.9	-
Pumpkin seed, peeled	5.8	5.93 ± 1.0	1.94 ± 0.1	1.40 ± 0.0	9.20 ± 1.0	6.0[1]
Sesame seed, whole	4.0	8.56 ± 0.0	2.42 ± 0.2	1.03 ± 0.0	12.0 ± 0.2	12.3[4]
Sesame seed, peeled	3.4	7.22 ± 0.2	1.55 ± 0.0	1.73 ± 0.1	10.4 ± 0.1	11.3*
Sunflower seed, peeled	4.4	9.51 ± 0.4	1.34 ± 0.5	0.72 ± 0.0	11.5 ± 0.8	6.0[4]
Vegetables						
Carrot	88	1.76 ± 0.1	0.61 ± 0.0	<0.2	2.37 ± 0.0	2.5[5]
Coriander	93	1.85 ± 0.3	0.46 ± 0.1	<0.2	2.31 ± 0.2	2.8[1]
Horseradish	75	5.97 ± 0.0	0.72 ± 0.0	<0.2	6.69 ± 0.0	7.5[6]
Lamb´s lettuce (corn salad)	96	0.97 ± 0.1	0.17 ± 0.0	<0.2	1.15 ± 0.1	1.8[4]
Lettuce	95	1.44 ± 0.0	0.16 ± 0.0	<0.2	1.60 ± 0.0	1.0[5]
Peashoot	92	2.16 ± 0.2	0.30 ± 0.0	<0.2	2.46 ± 0.2	1.6*
Radicchio	96	1.09 ± 0.0	0.20 ± 0.0	<0.2	1.29 ± 0.0	1.1[7]
Red onion	87	1.13 ± 0.0	0.85 ± 0.0	4.37 ± 0.1	6.35 ± 0.1	2.0[4]
Romaine lettuce	96	1.24 ± 0.1	0.17 ± 0.0	<0.2	1.41 ± 0.1	1.8[4]
Rucola (salad rocket)	94	1.76 ± 0.0	0.30 ± 0.0	<0.2	2.06 ± 0.0	1.6[1]
Tomato (domestic, winter)	94	1.11 ± 0.1	0.18 ± 0.0	<0.2	1.29 ± 0.1	1.4[5]
Tomato (imported)	92	2.42 ± 0.0	0.11 ± 0.0	<0.2	2.53 ± 0.0	1.4[5]
White radish (daikon)	95	1.21 ± 0.0	0.09 ± 0.0	<0.2	1.30 ± 0.0	1.6[1]
Fruits						
Apple (green), with skin	85	1.73 ± 0.0	0.68 ± 0.0	<0.2	2.41 ± 0.0	1.5[5]
Apple (green), pealed	86	1.21 ± 0.0	0.60 ± 0.0	<0.2	1.81 ± 0.0	1.8[8]
Apple (red), with skin	86	1.50 ± 0.0	0.18 ± 0.1	<0.2	1.68 ± 0.1	1.5[5]
Apple (red), pealed	85	1.26 ± 0.0	0.22 ± 0.1	<0.2	1.48 ± 0.1	1.8[8]
Banana, pealed	75	3.09 ± 0.2	0.30 ± 0.0	0.20 ± 0.1	3.59 ± 0.1	1.8[5]
Blackcurrant	76	5.44 ± 0.8	1.02 ± 0.1	<0.2	6.46 ± 0.8	5.8[5]
Blueberry	85	4.21 ± 0.1	0.25 ± 0.1	<0.2	4.46 ± 0.1	3.3[3]
Cloudberry	85	5.44 ± 0.3	0.30 ± 0.0	<0.2	5.74 ± 0.4	6.3*
Lingonberry	85	2.32 ± 0.2	0.63 ± 0.1	<0.2	2.95 ± 0.2	2.6[3]
Raspberry	87	3.92 ± 0.2	0.32 ± 0.1	<0.2	4.24 ± 0.2	3.8*
Strawberry	89	2.44 ± 0.3	0.28 ± 0.1	<0.2	2.76 ± 0.2	1.9[5]
Mushrooms						
Chanterelle	89	3.51 ± 0.2	0.31 ± 0.0	<0.2	3.82 ± 0.2	3.2[4]
Edible boletus	91	1.86 ± 0.2	0.38 ± 0.1	<0.2	2.24 ± 0.1	3.0*
Funnel chanterelle	90	4.20 ± 0.2	0.34 ± 0.1	<0.2	4.54 ± 0.2	3.2*
Northern milk-cap	95	2.43 ± 0.3	0.18 ± 0.0	<0.2	2.61 ± 0.3	1.5[9]
Other						
Seaweed Nori	6	21.9 ± 0.2	13.1 ± 0.4	<0.2	35.0 ± 0.2	44.4[6]

526

527 References behind the DF values in Fineli Food Composition Database (release 17): *value created within host-system,
528 [1]Borrowed value from USDA, [2]Callaway (2004), [3]Independent laboratory, [4]Borrowed value from Livsmedelsverket,
529 [5]Plaami et al. (1992), [6]McCance & Widdowson (1960), The composition of foods, [7]Danish Food Composition Databank,
530 [8]Moller & Saxholt (1996), [9]Mattila et al. (2002)

531 Limit of quantification (LOQ) for SDFS was 0.2 g/100 g (LOD 0.1 g/100 g), results under LOQ are expressed as <0.2.

532